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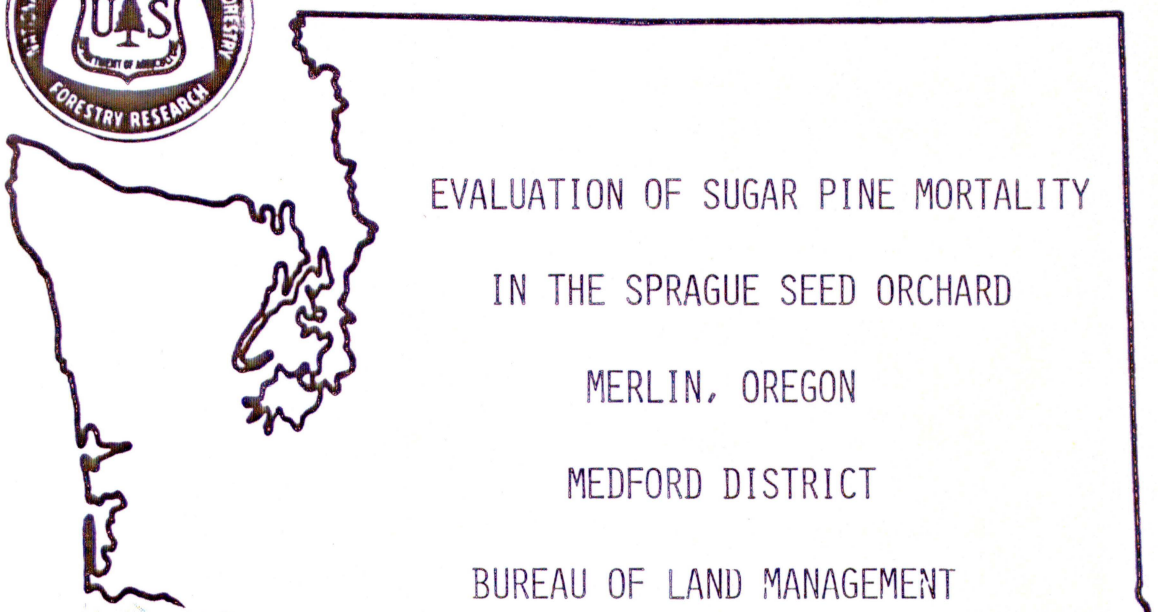
# Forest Pest Management
# Pacific Northwest Region



EVALUATION OF SUGAR PINE MORTALITY

IN THE SPRAGUE SEED ORCHARD

MERLIN, OREGON

MEDFORD DISTRICT

BUREAU OF LAND MANAGEMENT

# EVALUATION OF SUGAR PINE MORTALITY IN THE SPRAGUE SEED ORCHARD, MERLIN, OREGON, MEDFORD DISTRICT, BUREAU OF LAND MANAGEMENT

by

Gregory M. Filip and Borys M. Tkacz

## ABSTRACT

Twenty-five recently-killed or symptomatic sugar pines were examined thoroughly for cause of damage. Total excavation of root systems revealed the presence of misshapen root systems, infections by *Armillaria mellea*, and root collar infestations by weevils (*Pissoides* sp.) in many of the dead and dying trees. A subsample of 6 root systems was cultured; an unidentified species of *Phytophthora* was isolated from 5 of 6 root systems. Most mortality was associated with poorly drained areas. Recommendations for disease management are presented.

## INTRODUCTION

The Sprague Seed Orchard is operated by the Medford District of the Bureau of Land Management primarily for the production of seed from superior-growing and blister rust-resistant sugar pines (*Pinus lambertiana*). Most of the orchard was planted 15 to 20 years ago, and grafted scions are approaching cone-bearing age.

Substantial amounts of tree mortality have occurred recently in the orchard. Because of the loss of high-value, established trees and the concern for mortality in recently-planted portions of the orchards, orchard personnel requested assistance from the USDA Forest Service, Forest Pest Management pathologists in Portland.

On October 8, 1980, sugar pine mortality was examined by Sally Cooley, Forest Pest Management Pathologist. Armillaria root rot, caused by *Armillaria mellea*, was found on several of the dead trees. It was recommended that the orchard be examined in greater detail to confirm cause of tree mortality, characterize infection and spread, and formulate control measures.

On December 2-3, 1980, the orchard was more intensively examined with the following objectives: (1) determine causes of tree mortality, and (2) formulate management recommendations to prevent mortality.

## METHODS

Twenty-five recently-killed or dying trees (ave. DBH = 3 in.) were selected randomly for examination within the seed orchard. This sample represented about two-thirds of the recently-killed and symptomatic trees. Root systems of all trees were excavated totally with a hydraulic excavator (Fig. 1). The following data were recorded for each tree: (1) identification number, (2) needle condition (chlorotic or red), (3) origin (root stock or progeny, (4) root condition (live, dead, or misshapen), (5) extent of root disease, and (6) presence of insect attacks.

In addition, 6 entire root systems from chlorotic trees (those with some living roots) were returned to the laboratory for isolation of disease-causing organisms. Roots with living tissue were washed, bark was removed aseptically, and wood chips from the interface between living and dead tissue (Fig. 2) were removed with a wood gouge and placed on either potato dextrose agar (PDA) or corn meal agar amended with 20 ppm of pimaricin (CMAP) which is selective for pythiaceous fungi (water molds). Water molds, especially *Phytophthora* spp., were suspected because of the characteristic necrotic tissue they cause in infected roots (Fig. 2). After one week, fungal growth from CMAP was transferred to corn meal agar (CMA) without pimaricin. Wood chips were placed similarly on media selective for *Armillaria mellea* (Shaw and Roth 1976). In addition, fine, dead roots from each root system were macerated and placed into cored apples to selectively isolate water molds (Hansen et al 1979). Necrotic apple tissue appearing after 2 weeks was transferred to CMA. All suspected cultures of *Phytophthora* were sent to Oregon State University, Corvallis, to confirm identification.

## RESULTS AND DISCUSSION

Of the 25 trees excavated and examined, 15 were of rootstock origin and 10 were of progeny origin (Table 1); hence, there appeared to be no correlation between tree origin and mortality. Seven trees were chlorotic with drooping needles, 11 had red needles with some green but chlorotic branches, and 7 were completely red.

Examination of root systems showed that 14 appeared normal (some were small), but 11 were either curled (Fig. 3), j-rooted, or constricted. Orchard personnel commented that several trees were left in pots for 6 to 7 years before planting. This could have resulted in the curled and constricted root systems. Eighteen trees had root systems that were completely dead, while the remainder had both dead and living roots. No trees with completely living root systems were found, even though 7 trees were still green, although chlorotic, when excavated.

Although Armillaria root rot was expected to be the major cause of tree mortality in the orchard, only 7 of 25 trees were affected, and most root systems were less than half infected (Table 1). Weevil (*Pissoides* sp.) chip cocoons were found at the root collars of 2 dead trees (Fig. 1).

Isolation of fungi from root systems revealed the presence of *Phytophthora* sp. on 5 of 6 root systems. Based on our subsample, most of the dead and symptomatic trees in the orchard probably are infected with *Phytophthora* sp. Although not identified to species yet, the cultures obtained are not *P. cinnamomi* but resemble *P. cryptogea*.

*Phytophthora* spp. are serious world-wide pathogens damaging diverse crops such as avocados, eucalyptus, and shortleaf pine. *Phytophthora lateralis* currently is threatening Port-Orford cedar as a commercial timber species in southern Oregon (Roth et al 1972). *Phytophthora cryptogea, P. drechsleri, P. megasperma*, and *P. cactorum* are causing occasional losses in Douglas-fir nurseries throughout the Pacific Northwest (Hansen et al 1979). *Phytophthora cinnamomi* causes damage to short leaf and loblolly pine in the southern U.S. (littleleaf disease) and ornamentals and Christmas trees in the Pacific North-

west. Although *P. cinnamomi* has been reported to cause damage in sugar pine nurseries (Hepting 1971), it has not been reported on saplings or larger trees in Oregon or California.

In Douglas-fir nurseries, damage is more severe in transplant beds than in seed beds and is more damaging in poorly drained areas (Hansen et al 1979). The fungi are transported in surface water as zoospores (swimming spores). Oospores and chlamydospores (resting spores) are believed to be spread from area to area in mud and soil as seedlings and equipment are moved about (Roth et al 1972).

*Phytophthora* spp. have a history of causing damage in nurseries growing on former agricultural fields with diverse cropping histories including vegetables, small fruits, and grains (Hansen et al 1979). The Sprague Seed Orchard is established on forest land previously occupied by oak and ponderosa pine, hence inoculum may not have been present prior to orchard establishment but may have been introduced from the roots and potting mixture of transplanted trees.

Eradication of resting spores of *Phytophthora* spp. by fumigants or fungicides is not completely effective. Best control is achieved with adequate drainage and restricted movement of infested soil and stock, coupled with fumigation of previously infested soil.

## CONCLUSIONS

The major cause of mortality in the Sprague Seed Orchard appears to be *Phytophora* sp., especially in poorly drained areas. Soil in the orchard is a heavy red clay with poor drainage, especially in B.U. 54 (Fig. 4). Sugar pine grows best on "light-brown to reddish-brown, slightly to moderately acid, silt loams and clay loams derived from sandstone and shale. The poorest stands usually grow on red clay loam developed in place from weathering of peridotite and related ultrabasic rocks which in places have developed serpentine characteristics" (Fowells 1965). Optimum moisture for sugar pine is on the dry side, similar to that for incense cedar (Minore 1979).

Other factors that may be contributing to tree mortality or causing stress on orchard trees include the following:

1. Almost half of the trees examined had misshapen root systems caused by improper or delayed planting.

2. Some of the trees were infected by *Armillaria mellea* or infested by weevils. *Armillaria mellea* can cause mortality of plantation trees (Filip and Goheen 1978), but in the Sprague Seed Orchard, *A. mellea* appears to be attacking root systems already weakened by other factors, possibly infection by *Phytophthora* sp. *Armillaria mellea* development on infected root systems was sparse and appeared too fresh to have caused tree mortality. Weevils commonly attack boles and root collars of dying trees.

3. Seed source for all of the trees examined was at 4,000 feet elevation. Orchard elevation is 1,200 feet. Elevation range for sugar pine in southern Oregon is 1,100 to 5,400 feet. Besides being planted at a lower elevation than parental trees, orchard trees are growing at the lower end of the elevation range of the species.

## RECOMMENDATIONS

Many of the factors contributing to the mortality cannot be corrected entirely; consequently, the following recommendations are concerned with improving soil drainage and minimizing disease spread.

### Established Trees

1. When soil is wet, movement of machinery and personnel within the orchard should be restricted to established roads to prevent the spread of soil containing fungus inoculum from infested sections of the orchard to uninfested portions. Grass cover should be maintained to prevent soil exposure and movement.

2. Unless conditions become so dry that tree mortality will result, irrigation during the summer should be discontinued. Summer irrigation enhances moisture conditions that are favorable for the spread of and infection caused by *Phytophthora*.

3. Poorly drained areas should be tiled to improve drainage and reduce the population of water molds and subsequent root infections and mortality. Care should be taken to minimize root damage when laying tile near established trees.

4. Limited use of fungicides specifically toxic to water molds can be applied to established trees that are adjacent to areas of mortality. Fungicide drenches may reduce tree infection and prolong the life of infected trees until such time as stock of similar origin can be replicated elsewhere in the orchard. Use of fungicides should be seen strictly as a short term solution that in all probability will not result in long-lasting control. They would have to be used repeatedly. The long-term answer is to improve the soil drainage.

### New Plantings

1. Poorly-drained or low-lying areas should be avoided when planting.

2. If poorly-drained areas are to be planted, they should be tiled to improve drainage and tree vigor.

3. Trees should be planted as soon as possible, rather than retained in pots, to prevent root constriction and curling. This is now standard practice in the orchard.

4. Avoid unnecessary irrigation that may lead to favorable conditions for fungus spread and infection.

Forest Pest Management pathologists are available to assist orchard personnel in designing and implementing selected management measures. Concurrently, fungal pathogenicity and epidemiology as well as host-parasite-site relationships should be studied further, since the situation in the Sprague Seed Orchard may be somewhat unique. Pathologists from Oregon State University are available to address these problems in cooperation with Forest Pest Management pathologists.

The information and recommendations presented in this report have been specifically formulated for the orchard we surveyed. Although some of this information may be applied to other orchards in Oregon and Washington experiencing similar root disease problems, these areas may be sufficiently different from the area we surveyed to warrant a separate biological evaluation to formulate management alternatives specific to that orchard. FPM pathologists encourage and are available to perform such evaluations at the request of orchard managers.

## REFERENCES


Filip, G. M. and D. J. Goheen
1978. Incidence of and damage caused by root diseases in Douglas-fir plantations on the Quilcene Ranger District, Olympic National Forest, Washington, 20 p.

Fowells, H. A.
1965. Silvics of forest trees of the United States. Agric. Handbook No. 271, USDA Forest Service, Washington, D.C., 762 p.

Hansen, E. M., P. B. Hamm, A. J. Julis, and L. F. Roth
1979. Isolation, incidence and management of Phytophthora in forest tree nurseries in the Pacific Northwest. Plant Dis. Rept. 63:607-611.

Hepting, G. H.
1971. Diseases of forest and shade trees of the United States. Agric. Handbook #386, USDA Forest Service, Washington, D.C., 658 p.

Minore, D.
1979. Comparative autecological characteristics of northwestern tree species---a literature review. Gen. Tech. Rept. PNW-87, PNW Range and Exp. Sta., USDA Forest Service, Portland, Oregon. 72 p.

Roth, C. F., H. H. Bynum, and E. E. Nelson
1972. Phytophthora root rot of Port-Orford cedar. Forest Pest Leaflet #131, USDA Forest Service, 7 p.

Shaw, C. G. III and L. F. Roth
1976. Persistence and distribution of a clone of Armillaria mellea in a ponderosa pine forest. Phytopathology 66:1210-1213.

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Table 1--Data collected on 25 sugar pine trees in the Sprague Seed Orchard

| Tree No. | Origin | Needle Condition | Root Shape | Root Condition | Root Disease | Insect Activity | Cultured[b] |
|---|---|---|---|---|---|---|---|
| 54-1304 | Rootstock | Red + Chlor. | Normal | Dead | AM(20)[a] | None | |
| 54-0705 | Progeny | Red + Chlor. | Normal | Dead | None | None | |
| 54-0206 | Rootstock | Red + Chlor. | Normal | Dead | None | Weevils | |
| AR-4830 | Rootstock | Red | Constricted | Dead | None | None | |
| AR-4735 | Rootstock | Red | Normal | Dead | None | None | |
| AR-4734 | Progeny | Red | Curled | Dead | None | None | |
| AR-4736 | Progeny | Chlor. | Curled | Dead | None | None | No pathogen |
| AR-4517 | Rootstock | Red | Curled | Dead | None | None | |
| AR-4308 | Progeny | Red | Curled | Dead | AM(25) | None | |
| AR-3809 | Rootstock | Red | Curled | Dead | None | None | |
| AR-5309 | Rootstock | Chlor. | Normal | Dead + Live | None | None | Phytophthora Armillaria |
| AR-5708 | Progeny | Chlor. | Curled | Dead | AM(35) | None | Phytophthora |
| 54-1121 | Progeny | Chlor. | Curled | Dead | None | None | Phytophthora |
| 54-1123 | Progeny | Chlor. | Normal | Dead | None | None | Phytophthora |
| 54-1552 | Rootstock | Red | Normal | Dead | None | None | |
| 54-2952 | Rootstock | Red | Normal | Dead + Live | AM(20) | None | |
| 54-3248 | Rootstock | Red | Curled | Dead | AM(50) | Weevils | |
| 54-3250 | Rootstock | Red + Chlor. | Normal | Dead + Live | None | None | Phytophthora |
| 54-3157 | Progeny | Red + Chlor. | J-Root | Dead + Live | None | None | |
| 54-3353 | Progeny | Red | Normal | Dead | AM(90) | None | |
| -3451 | Rootstock | Red | Normal | Dead | None | None | |
| -3651 | Rootstock | Red | Normal | Dead | None | None | |
| -3450 | Rootstock | Red + Chlor. | Normal | Dead + Live | AM(50) | None | |
| 54-3349 | Progeny | Chlor. | Normal | Dead + Live | None | None | |
| 54-3348 | Rootstock | Chlor. | Curled | Dead + Live | None | None | |

| Total No. | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | Rootstock-15<br>Progeny-10 | Chlorotic-7<br>Red+Chlor.-11<br>Red-7 | Normal-14<br>Curled-9<br>J-Root-1<br>Constr.-1 | Dead-18<br>Dead+Live-7<br>Live-0 | AM-7(41) | Weevils-2 | Phytoph.-5<br>Armillaria-1 |

[a] Number in parentheses is approximate percentage of root system infected by *Armillaria mellea* (AM)

[b] Only six trees were cultured

Fig. 1--Root system of a dead tree infested with weevils.

Fig. 2--Necrotic tissue in the root of a dying tree infected by *Phytophthora* sp.

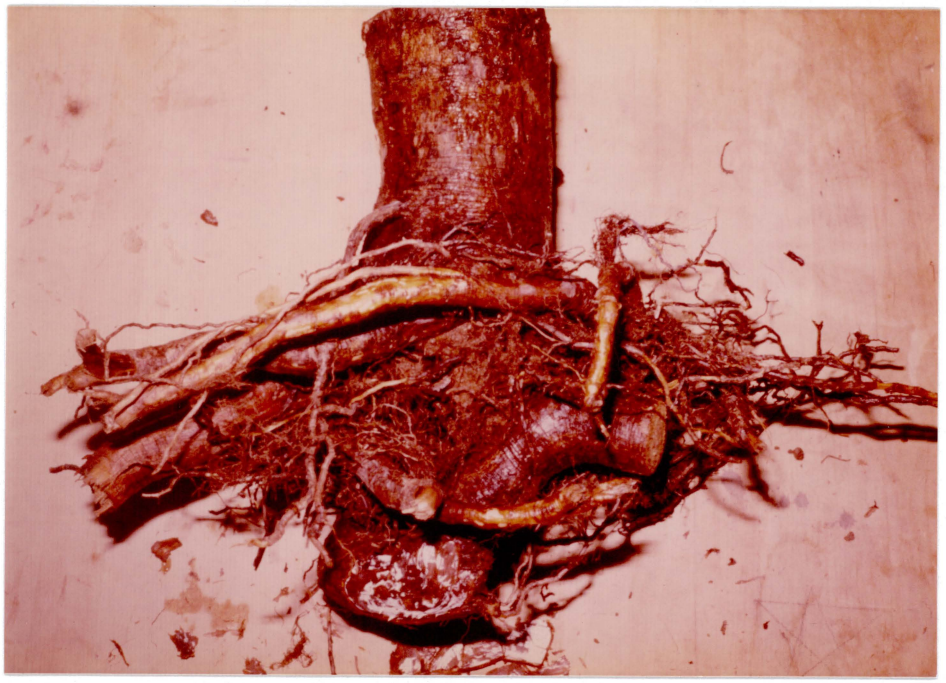

Fig.3--Curled root system of a dead tree as a result of being kept in pots 6-7 years before planting. Note white mycelian fans of *Armillaria mellea* at base of root system.